DEVELOPMENT AND EVALUATION OF DIABETES SELF-MANAGEMENT EDUCATION AND SUPPORT (DSMES) mHEALTH ON NUTRITIONAL STATUS AND KAP OF TYPE 2 DIABETES MIZO TRIBAL ADULTS

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Introduction

Diabetes mellitus, particularly Type 2 Diabetes mellitus (T2DM), poses a significant public health challenge globally, with India bearing a disproportionate burden due to rising prevalence, poor glycaemic control, and socioeconomic disparities (Mathur et al., 2022). A critical barrier to effective diabetes management is the lack of patient knowledge regarding treatment adherence and self-care practices, such as dietary modifications, physical activity, and foot care. Rural studies highlighted that diabetic patients are often unaware of target glucose levels, confused about dietary advice, and lack guidance on essential self-care practices, leading to poor health outcomes (Anitha et al., 2019).

The tribal populations of India, including the Mizo tribal community, face unique challenges in diabetes management due to cultural, genetic, and geographical barriers (Lalrohui et al., 2020, 2021). Diabetes Self-Management Education/Support (DSMES) has proven effective in improving glycaemic control, reducing complications, and enhancing quality of life. However, its implementation remains limited, especially in low-resource and tribal settings (Beck et al., 2018, and Hazarika et al., 2022)

Digital health interventions, including mobile apps and social media-led education, offer promising solutions to bridge the gaps in access and adherence (WHO, 2019). Health literacy and social support play the crucial roles in effective diabetes management (Abbasi et al., 2018) and emphasized the need for culturally tailored DSMES programs (Davis et al., 2022). Knowledge, Attitudes, and Practices (KAP) assessments highlight persistent gaps in diabetes awareness, necessitating targeted educational interventions (Wan et al., 2016). Additionally, Medical Nutrition Therapy (MNT) and lifestyle modifications are essential for glycemic control, yet individualized approaches are required to address diverse dietary habits and socioeconomic constraints (Davis et al., 2022).

Statement of the problem

India, known as the "diabetes capital of the world," has 1 in 10 adults with diabetes, including tribal populations facing rising cases due to genetic, lifestyle, and socioeconomic factors. While Diabetes Self-Management Education and Support (DSMES) improves outcomes, its reach remains limited in underserved areas like the Mizo tribal community. To mitigate India's growing diabetes crisis, a multi-faceted approach is needed to strengthen the primary healthcare, integrating digital DSMES tools, enhancing health literacy, and implementing culturally adapted interventions, particularly for vulnerable tribal populations.

Scope of the study

This study aimed to bridge this gap by creating a culturally adapted DSMES toolkit and integrating it into a mobile health (mHealth) application to address challenges such as low health literacy, remote access, and healthcare shortages. By assessing its effect on knowledge, attitudes and practices (KAP) and nutritional status, the research demonstrate the feasibility of digital DSMES solutions in tribal settings. The intervention incorporated local dietary habits, language, and traditions to ensure relevance and long-term adoption, offered a scalable model for diabetes care in marginalized populations.

Objectives of the Study

The objectives of the study are presented below

Primary Objectives

- To develop and evaluate DSMES mHealth application for Type 2 diabetes Mizo tribal adults.
- To evaluate the effect of DSMES mHealth intervention on the nutritional status and KAP of Type 2 diabetes Mizo tribal adults.

Secondary objectives

- To develop and validate DSMES toolkit for Type 2 diabetes Mizo tribal adults
- To develop DSMES mHealth application for Type 2 diabetes Mizo tribal adults
- To validate the acceptance of DSMES mHealth among Type 2 diabetes Mizo tribal adults.

- To assess and compare the knowledge, attitudes, practices (KAP), and nutritional status of the selected Type 2 diabetes attending public and private clinics.

Methodology

Different methodological procedures adopted for the study have been presented about the choice of research approach, description of settings, selection of participants based on the formula of sample size calculation method, the construction of tools, methods of data collection and analysis. In light of the collated literature, and studies discussed in the earlier chapter, the methodology of the study is presented into four phases –

Phase 1: Development and Validation of the DSMES Toolkit

The Diabetes Self-Management Education and Support (DSMES) toolkit was systematically developed using the ADCES7 framework, which outlined seven essential self-care behaviours for diabetes management. These behaviours include Healthy Coping, Healthy Eating, Being Active, Taking Medication, Monitoring, Reducing Risk, and Problem Solving. The modules were structured to progress from foundational concepts to advanced self-management strategies, ensured a comprehensive approach. The toolkit was first made in English and then translated by linguistic experts. Cultural relevance was prioritized by incorporated Mizo language, local dietary examples, and familiar illustrations. Interactive elements such as visual portion guides, step-by-step instructional videos, and practical tools like medication schedule were integrated to enhance user engagement and comprehension.

Validation was conducted through a rigorous multi-stage process. First, face validity was assessed by a multidisciplinary panel of experts, including dietitians, psychologists, pharmacists, and health workers, alongside feedback from diabetic patients to ensure clinical relevance and practicality. Linguistic experts further refined the materials to guarantee clarity and cultural appropriateness. Next, readability was evaluated using seven standardized formulas (e.g., Flesch-Kincaid, SMOG Index) to confirm the content was accessible to individuals with a below 5^{th} grade reading level in both English and Mizo. The Suitability Assessment of Materials (SAM) tool was employed to rate the toolkit across key domains—content, literacy demand, graphics, layout, and cultural relevance. For each factor, SAM rated the materials Superior, Adequate or Not Suitable based on objective criteria included in the instrument. Superior ~ 2 points, Adequate ~ 1 and Not Suitable ~ 0. To add more value of the

validation of the toolkit **,** assessing the inter-rater reliability between the two experts the study employed Cohen's kappa, a reliable statistical measure, to assess inter-rater reliability between two raters.

Phase 2: Development of DSMES mHealth Application

The validated toolkit was adapted into the "Zunthum Puitu" mobile health application to improve accessibility, particularly for rural populations in Mizoram with limited clinic access. The app development followed a structured approach: initial conceptualization based on the toolkit, low-fidelity prototyping using paper and pen, iterative high-fidelity design refinements with figma an online digital tools, and backend/frontend development. Key features included secure mobile number authentication with OTP verification, personalized profile setup, and interactive health management tools such as a BMI calculator, blood reports, and medication schedules. The app also incorporated culturally tailored diet planning tools, including visual diabetic plates and customisable meal plans, as well as exercise goal-setting features and a tobacco dependency test based on the Fagerström scale.

To assess user acceptance, the Technology Acceptance Model (TAM) was applied, measuring perceived usefulness and ease of use through a Likert-scale questionnaire administered to 256 diabetic patients in Aizawl. To confirm the relevance of the measurement model, first, reliability was considered using Cronbach alpha**.** Secondly, the content validation was guaranteed by using items from the earlier study, and construct validity was assured using convergent validity and discriminant validity. Convergent validity were tested by Composite reliability (CR) and average variance extraction (AVE). For Discriminant validity, ensuring that the square roots of the AVEs were greater than the intercorrelations between the construct and the other constructs served as a test for the model. Lastly, the structural model was assessed by testing the hypotheses using a standardized path coefficient and t-statistics with regression analysis.

Phase 3: Assessment and Implementation of DSMES mHealth Intervention

The DSMES mHealth intervention was implemented among 120 selected participants (60 control, 60 experimental) from public and private diabetic clinics in Mizoram. The sample size was determined to be 120, based on the diabetes prevalence rate of 5.7 % (ICMR,2012), with a 95% confidence level and 5% margin of error. Participants included were aged 30-50 years

with HbA1c levels between 6.5-10%, while excluding those with critical illnesses or without Android phone access. The experimental group received the standard diabetic care along with DSME/S counselling based on the Knowledge, Attitude and Practice assessments, which serve as a foundation for heathy coping . The intervention is then followed with DSMES mHealth app "Zunthum Puitu" which allowed the selected participants to accessed the 18 DSMES modules, BMI calculator, Tobacco dependency test, medication schedules and sample diet plan. This group also received monthly telephonic follow-ups and weekly WhatsApp reminders with meal tips and module reviews. The control group received only standard diabetic care without any diabetes self-management education and dietary intervention. Comprehensive baseline assessments were conducted in terms of socio-demographics such as age, gender, marital status, educational status and socio economic status using the Modified Kuppuswamy Scale. Nutritional status assessment included the anthropometric measurements including BMI and WHR, bio-markers like HbA1c and lipid profiles, clinical symptoms of hypoglycaemia and hyperglycaemia, dietary intake through 3-day recall method. For the assessment of knowledge, attitude and practice validated questionnaires such as the short knowledge diabetes instrument (SKDI), third version of the Diabetes Attitude scale and the Modified summary of diabetes self-care activities. Statistical analysis using SPSS version 26.0 compared outcomes between public and private clinic participants. Quantitative data was analysed using t-tests and, while qualitative data was examined through chi-square test. The association of Knowledge, Attitude and Practices was also analysed using chi-square test.

Phase 4: Effect of DSMES mHealth Intervention on selected study participants

After three months of intervention, post-assessment was conducted to evaluate its effectiveness in both the control and experiment group participants. The nutritional status was reassessed through anthropometric measurements and bio-markers. Changes in HbA1c level and clinical symptoms of hypoglycaemia and hyperglycaemias were reviewed to assess improvements in glycemic control. Dietary intake was re-evaluated using the 3-day recall method to identify any positive changes in eating habits. The knowledge, attitude and practice (KAP) of the study participants regarding diabetes self-management were reassessed using the same validated tools to measure improvements in their knowledge and attitude and application of diabetes care principle in their day-to day life. In the post assessment 20 participants were lost for the post follow-up assessment the intervention and 100 study participants completed the post intervention assessment. Statistical analysis using SPSS version 26.0 compared outcomes,

before and after DSMES mHealth intervention and between control and experimental groups, as well as between public and private clinic study participants. Data was analysed using ANCOVA, to determine the intervention's effectiveness in improving the diabetes self-management outcomes between the clinic types(private vs public) and intervention groups(control vs experiment) and if there is any interaction between the study groups and intervention groups. The comprehensive evaluation aimed to demonstrate the effect of the DSMES mHealth intervention on enhancing diabetes care knowledge, promoting positive health behaviours, and improving clinical outcomes among the study population.

Original contribution

Salient findings of the study with key conclusions of the current study are summarised below:

The Diabetes Self-Management Education toolkit demonstrated excellent readability across all 18 modules, with the scoring at a 2^{nd}-5^{th} grade level, making it highly accessible for the Mizo diabetic population. Key modules like Checking Blood Sugar, Low Blood Sugar, What to Eat? and Using Plate to Control Portion Size achieved perfect readability scores of 100%, while other modules maintained strong clarity with mean scores ranging from 86 to 100%. The comprehensive readability assessment using seven validated indices confirmed that the materials were appropriately simplified without losing essential educational content, ensuring comprehension even among individuals with basic literacy skills.

Validation of the toolkit's suitability through the Suitability Assessment of Materials (SAM) showed that all the developed modules rated as "superior" with scores exceeding 80%. Two independent raters, experts in medicine and nutrition, showed substantial to perfect agreement (Kappa values 0.64-1.00), particularly for nutrition-focused modules which scored highest. The strong inter-rater reliability and consistently high suitability scores across all modules confirmed the toolkit's effectiveness in delivering culturally relevant diabetes education tailored to the Mizo population's needs and literacy levels.

Initially, evaluation of the DSMES mHealth application's acceptability revealed the overwhelmingly positive user perceptions among 256 diabetic participants. Over 80% found the app useful for improving their quality of life and healthcare convenience and reported it was easy to use. Approximately almost 80% expressed clear intentions to adopt the technology within three months, indicating strong potential for sustained engagement. These high

acceptance rates suggested the app successfully translated the validated toolkit content into a user-friendly digital format that meets the population's needs.

The Technology Acceptance Model (TAM) analysis provided robust statistical confirmation of the mHealth application's strong design foundations. All constructs demonstrated excellent reliability (Cronbach's $\alpha > 0.90$) and convergent validity (AVE >0.66), with discriminant validity confirming each construct's distinctiveness. Structural equation modelling revealed perceived ease of use had a particularly strong influence ($\beta = 0.72$) on perceived usefulness, which together explained 68.9% of variance in adoption intention. These results aligned with established technology adoption theories and confirmed the app's design effectively addressed key determinants of successful mHealth implementation.

The findings collectively demonstrated both the DSMES toolkit and mHealth application are well-designed, culturally appropriate interventions ready for implementation in Mizoram's diabetes care programmes. The toolkit's superior readability and suitability scores, combined with the app's high acceptability and strong TAM validation, provide compelling evidence for their potential to improve diabetes self-management. These results support broader deployment across healthcare facilities, particularly in rural areas with limited diabetes education resources, while suggesting the intervention model could be adapted for other chronic diseases or regional populations with similar needs.

Socio-Demographic Profile of Selected Diabetes Participants

The study included 154 type 2 diabetes participants (80 from public clinics, 74 from private clinics) aged 30–50 years who met the inclusion criteria. No significant differences were found in age ($p=0.506$) or gender ($p=0.431$) between clinic types, with 62% of study participants in the age group 40-50 years and a near-equal gender distribution. However, significant differences emerged in residence ($p<0.001$), education ($p<0.001$), and socioeconomic status ($p<0.001$). Private clinic study participants were predominantly from urban (92%) areas and were more educated (36% graduates), and 85% belonged to the upper-middle class, while public clinic participants were more from rural areas (51%), less educated (23% graduates), and 58% in the upper-lower class.

Diabetes Self-Management Knowledge, Attitude, and Practices (KAP)

- Knowledge: Private clinic participants scored significantly higher (mean=7.71) than public clinic participants (mean=6.92, p=0.011), though both groups had suboptimal knowledge (max score=13). These studies showed better health literacy in private healthcare users.
- Attitude: No overall difference in attitude scores (p=0.820), but private clinic participants perceived diabetes as more serious (p<0.001) and valued tight glucose control more (p=0.043). Both groups acknowledged the need for specialised training (mean=4.75/5).
- Practices: No significant differences between clinic types (p=0.814). Poor adherence was noted: 55% consumed restricted foods frequently, 51% were inactive, 61% did not monitor blood sugar, and 98% neglected foot care. Tobacco use was prevalent (23% smokers, 20% tobacco chewers), highlighting gaps in self-care.

Association of KAP with Socio-Demographics

- Residence: No significant associations with KAP, suggesting these factors minimally influence diabetes management behaviours.
- Education: Higher education correlated with better knowledge (p=0.001) but not attitudes or practices, emphasising the role of formal education in health literacy.
- Socioeconomic Status: Upper-middle-class participants had more positive attitudes (p < 0.001). However, practices remained poor across all groups, indicating universal challenges in behaviour change.

Nutritional Status of the Study Participants

- Anthropometrics: Private clinic participants had higher BMI (26.85 vs. 25.25, p=0.009), weight (71.39 kg vs. 65.53 kg, p=0.001), and waist circumference (91.84 vs. 87.85 cm, p=0.007), suggesting obesity disparities linked to lifestyle or socioeconomic factors. Abdominal obesity (WHR > 0.9 males > 0.85 females) was prevalent in both groups (81%).
- HbA1c: Poor control (mean=8.62%), with no clinic differences (p=0.580). Only 29% achieved ideal levels (<7%).
- Lipids: High triglycerides (63%) and LDL (66%) and low HDL (45%) were common, with no clinic differences (p>0.05).

Clinical Profile and Dietary Intake

- Duration and Treatment: Forty-five per cent of the study participants had diabetes for 1–5 years, with 86% on oral medications and 14% on insulin, showing no clinic differences ($p>0.05$).
- Symptoms: Hyperglycaemia (thirst and frequent urination) and hypoglycaemia (irritability and fatigue) were common with no clinic variations ($p > 0.05$).
- Diet: The energy intake among male study participants was slightly higher in the public clinic group (2216.2 ± 418.13 kcal) compared to those in the private clinic (2089.96 ± 408.40 kcal). Female study participants from private clinics had marginally higher energy intake (1795.76 ± 455.02 kcal) than those from public clinics (1718 ± 465.31 kcal). However, the overall difference in total energy intake between the two clinic types was not statistically significant ($p = 0.911$), suggesting that energy consumption was similar across both settings of private and public clinics.
- In terms of carbohydrate intake, male study participants in the public clinic group consumed more (317.45 ± 94.61 g) than their private counterparts (290.35 ± 113.89 g), while female study participants in private clinics had slightly higher intakes (257.02 ± 68.45 g) than those in public clinics (243.46 ± 77.99 g). Despite these differences, the total carbohydrate intake did not significantly differ between the two study groups ($p = 0.889$), indicating comparable carbohydrate consumption.
- Protein intake was also analysed and showed that the male study participants from public clinics consumed more protein (71.23 ± 25.75 g) than males from private clinics (66.10 ± 25.78 g), while the intake among females was nearly the same in both the study groups. The overall protein intake showed no statistically significant difference ($p = 0.813$) and suggested that both the study groups had similar levels of protein intake relative to their dietary requirements.
- Fat intake showed minimal variation between public and private clinic study participants. Among males, the fat intake was 65.93 ± 25.55 g in the public group and 67 ± 32.28 g in the private group. Female study participants also showed similar values. The overall difference in fat intake was not significant ($p = 0.813$), reflecting consistent dietary fat consumption between both the study clinic groups.
- The only nutrient that showed a statistically significant difference was total dietary fibre. Male study participants in private clinics had slightly higher fibre intake (28.7 ± 8.24 g) compared to public clinics (28.02 ± 7.18 g). Among females, fibre intake was

also higher in the private group (26.91 ± 7.13 g) than in the public group (24.82 ± 5.15 g). The total fibre intake difference was found to be statistically significant (p = 0.013), suggesting that individuals from private clinics may have had diets richer in fibre, potentially due to better access to fruits, vegetables, or whole grains.

- Socioeconomic Disparities: Private clinic participants were from urban areas, educated, and belonged to a higher income group, yet obesity and poor glycaemic control were prevalent, suggesting lifestyle factors outweigh healthcare access advantages.
- Knowledge-Action Gap: Despite better knowledge in private clinics, self-care practices were poor universally, emphasising the need for behaviour-focused interventions.
- Metabolic Risks: High HbA1c, dyslipidaemia, and abdominal obesity highlighted the urgent needs for dietary and physical activity interventions across the study clinic groups.
- Intervention Targets: Culturally tailored DSMES programmes should address literacy gaps in public clinics and lifestyle modifications in private clinics, with emphasis on lifestyle intervention and diabetes self-care.

Effect of Diabetes self-management education/ and Support (DSMES) mHealth Intervention

I. Effect of Diabetes self-management education and Support mHealth Intervention on KAP and Nutritional Status

- The knowledge scores showed a significant improvement in the experimental group, which received the DSMES mHealth intervention. The mean score increased from (M = 7.63, SD = 1.91) to (M = 10.60, SD = 2.09), while the control group (standard medical treatment only) saw only a marginal increase from (M = 7.11, SD = 1.87) to (M = 7.47, SD = 3.07). ANCOVA analysis confirmed a strong group effect $F(1, 95) = 79.58$, $p < .001$, $\eta^2 = .456$, indicating that the intervention was highly effective in enhancing diabetes-related knowledge. There was no significant difference between public and private clinics (p = .299), suggesting that the intervention worked equally well in both settings.
- For attitudes, the experimental group improved from (M = 4.07, SD = 0.29) to (M = 4.37, SD = 0.27), whereas the control group had a smaller increase from (M = 3.99, SD = 0.26) to (M = 4.14, SD = 0.54). The group effect was statistically significant $F(1, 95) = 18.13$, $p < .01$, $\eta^2 = .160$, reinforcing that the intervention positively influenced

participants' attitudes toward diabetes management. There was no significant difference between public and private clinics (p = 0.09).

- Practice scores demonstrated the most dramatic improvement, with the experimental group increasing from (M = 10.32, SD = 3.09) to (M = 15.46, SD = 2.81), while the control group remained nearly unchanged (M = 10.70, SD = 2.64) to (M = 10.74, SD = 2.62). The ANCOVA results showed a highly significant group effect $F(1, 95) = 259.69$, $p < .001$, partial $\eta^2 = .732$, confirming that the intervention effectively promoted better diabetes self-management of the participants.

- In the control group, no significant changes were observed in self-management practices. In contrast, the intervention group showed significant improvements. There was a notable reduction in high-fat food intake, and consumption of fruits and vegetables increased. Physical activity, both general and specific exercise routines, also improved. Blood sugar testing, foot inspection, and shoe inspection all showed significant increases. Although tobacco smoking and paste consumption did not change, betel quid consumption significantly decreased. These findings demonstrate that the intervention successfully improved self-care practices in the selected participants.

- The BMI of the experimental group decreased from (M = 25.81, SD = 3.96) to (M = 24.70, SD = 3.45), whereas the control group showed almost no change (M = 25.35, SD = 2.92) to (M = 25.37, SD = 3.40). The group effect was not significant ($F(1,95) = 2.53$, $p = .115$, partial $\eta^2 = .026$), indicating that the intervention did not contribute to weight management.

- For Waist-to-Hip Ratio (WHR), the experimental group showed a slight but statistically significant reduction (M = 0.92, SD = 0.07) to (M = 0.91, SD = 0.07). There was also a significant main effect of groups on post-WHR ($F(1,95) = 5.71$, $p = .019$, $\eta^2 = .057$). In contrast, clinic type ($p = .396$) has no difference.

- The experimental group had a greater reduction in HbA1c (M = 8.25, SD = 1.55 to M = 7.47, SD = 0.93) compared to the control group (M = 8.12, SD = 1.62 to M = 8.00, SD = 1.43). ANCOVA confirmed a significant group effect ($F(1,96) = 9.84$, $p = .002$, partial $\eta^2 = .093$), indicating better glycaemic control with the intervention. The clinic type did not significantly influence the outcome (p = 0.051), meaning the intervention was effective in both public and private settings.

- The control group showed only modest improvements in symptoms related to poor glucose control, with small reductions observed across both public and private clinics. However, the experimental group**,** which received the DSMES intervention, showed significant improvements. Participants in this group reported sharp declines in symptoms such as excessive thirst, irritability, and fatigue. These results indicate that the DSMES intervention was effective in reducing diabetes-related symptoms, and no significant difference was observed in the effectiveness between clinic types.

- Energy intake decreased significantly in the experimental group (M = 1843, SD = 391 kcal to M = 1527, SD = 337 kcal) compared to the control group (M = 1837, SD = 444 kcal to M = 1810, SD = 418 kcal), $F(1, 95) = 15.31$, $p < .001$, $\eta^2 = .139$.

- Protein intake decreased more in the experimental group (M = 56.42, SD = 16.27 g to M = 50.99, SD = 13.17 g) than in the control group (M = 58.31, SD = 17.16 to M = 56.84, SD = 14.86). ANCOVA indicated that baseline intake was a significant covariate, $F(1, 95) = 20.61$, $p < .001$, $\eta^2 = .178$. However, the main effect of the group was not significant, $F(1, 95) = 3.75$, $p = .056$, $\eta^2 = .038$, suggesting that the reduction in the protein intake of the DSMES mHealth intervention was not significant as compared to the control group.

- Carbohydrate intake reduced significantly in the experimental group (M = 265.87, SD = 68.45 g to M = 214.47, SD = 56.54 g) compared with the control group (M = 255.55, SD = 72.17 g to M = 247.53, SD = 60.14 g), with the main effect on the group $F(1, 95) = 9.66$, $p = .002$, $\eta^2 = .092$. However, no significant difference between clinic type or interaction between clinic type and groups was observed.

- Fat intake also decreased significantly in the experimental group (M = 56.20, SD = 19.41 g to M = 46.53, SD = 13.40 g) compared with the control group (M = 55.82, SD = 20.12 g to M = 56.76, SD = 25.09 g), with a main effect on the group $F(1, 95) = 11.58$, $p = .001$, $\eta^2 = .109$. No significant difference between clinic type or interaction between clinic type and groups was observed.

- Total dietary fibre intake increased in the experimental group (Pre: M = 28.31, SD = 4.61; Post: M = 30.64, SD = 3.63), while remaining unchanged in the control group (Pre: M = 28.03, SD = 4.58; Post: M = 27.90, SD = 4.26). ANCOVA showed a significant group effect after adjusting for baseline intake, $F(1, 95) = 14.06$, $p < .001$, η^2

= .129. No significant difference between clinic type or interaction between clinic type and groups was observed.